STATEMENT

I, Futoshi Suzuki, a citizen of Japan, residing at 5-20, 5-chome, Noisshiki, Gifu-shi, Gifu-ken, Japan, hereby state that I am the translator of the attached document and I believe it is an accurate translation of the Japanese Patent Application Serial No. 2003-344873 entitled ORGANIC ELECTROLUMINESCENCE ELEMENT, filed on October 2, 2003, in the name of KABUSHIKI KAISHA TOYOTA JIDOSHOKKI.

Futoshi SUZUKI
Translator
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[Inventor]

[Address] c/o KABUSHIKI KAISHA TOYOTA JIDOSHOKKI, 2-1, Toyoda-cho, Kariya-shi, Aichi-ken

[Name] Yoshifumi KATO

[Applicant for Patent Application]

[Registration Number] 000003218

[Name] KABUSHIKI KAISHA TOYOTA JIDOSHOKKI

[Representative] Tadashi ISHIKAWA

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[List of Documents Attached]

[Name of Document] Scope of the Invention 1

[Name of Document] Specification 1

[Name of Document] Drawings 1

[Name of Document] Abstract 1

[Title of Document] Scope of the Invention

[claim 1] An organic electroluminescence element having an organic layer that can emit light at least by application of an electric field to a pair of electrodes, characterized in that

an electrode made of material having a higher volume resistivity in the pair of electrodes is formed in a flat form,

the organic layer has a plurality portions that do not emit light, and

the portions are provided so that an area occupied by the portions per unit area is greater at a position physically closer to a position of a terminal portion of the electrode made of material having the higher volume resistivity that is connected to an external connection terminal.

[claim 2] An organic electroluminescence element having an organic layer that can emit light at least by application of an electric field to a pair of electrodes, characterized in that

an electrode made of material having a higher volume resistivity in the pair of electrodes is formed in a flat form,

the organic layer has a portion that does not emit light, and

the portion is provided so that an area occupied by the portion per unit area is greater at a position physically further to a position of a terminal portion of the electrode made of material having the higher volume resistivity that is connected to an external connection terminal.

[claim 3] The organic electroluminescence element according to claim 1 or 2, being characterized in that an insulating layer is provided between at least one electrode of the pair of electrodes and the organic layer such that the portions that do not emit light do not emit light.

[claim 4] The organic electroluminescence element according to claim 1 or 2, being characterized in that the element has the organic layer provided only on the portions that emit light.

[claim 5] The organic electroluminescence element according to any one of claims 1 to 3, being characterized in that the portions that do not emit light in the organic layer are provided so that the luminance is substantially uniform in the whole.

[claim 6] The organic electroluminescence element according to any one of claims 1 to 3, being characterized in that the portion that emits light in the organic layer is provided so that the luminance is substantially uniform in the whole.

[Title of Document]Specification

[Title of the Invention] ORGANIC ELECTROLUMINESCENCE ELEMENT

[Technical Field]

[0001]

The present invention relates to an organic electroluminescence element having at least an organic layer held between a pair of electrodes.

[BACKGROUND OF THE INVENTION]

[0002]

Previously, displays, illuminators and the like using an organic electroluminescence element (hereinafter referred to as an organic EL element as appropriate) have been proposed. The organic EL element has a structure in which an organic layer having an organic light emitting region containing an organic light emitting material is held between a pair of electrodes.

[0003]

However, mere employment of the above structure does not lead to completion of the organic EL element, and for example, at least one electrode should be capable of injecting electric charges (holes or electrons) into the organic layer and have transparency to light emitted at the organic light emitting region for extracting light to outside the element. In addition, for the organic layer, a material transporting electric charges injected from the electrode, re-coupling the electric charges to create an excited state, and emitting light when turning from the excited state to a normal state should be selected.

[0004]

Therefore, materials for forming the organic EL element are extremely limited, and in most cases, there is no other choice but to use a material having a high volume resistivity for the transparent electrode and the organic layer.

Thus, there arises a problem so that the current density at the organic layer varies depending on the position.

A mechanism for this will be described below.

[0005]

Generally, an electrode on the side through which light is extracted to outside the element is composed of a material having a higher volume resistivity, such as ITO, and the other electrode is composed of a material of which the volume resistivity is negligible compared with the electrode on the light extraction side. Thus, when an infinite number of current routes in the organic EL element are considered, the length of passage over the electrode on the light extraction side on the routes may be examined.

If this examination is conducted, it will be apparent that a current route extending from a terminal portion of the electrode on the light extraction side through the electrode on the light extraction side to the other electrode by way of the organic layer at a position close to the terminal portion has a resistance value lower than that of a current route extending to the other electrode from the organic layer at a position distant from the terminal portion. That is, the current density in the organic layer at a position close to the terminal portion on the light extraction side is greater than the current density at a position distant from the terminal portion.

In this connection, the electrode on a side opposite to the light extraction side may be made of material having a volume resistivity higher than that of the electrode on the light extraction side. In this case, the position of the electrode on the light extraction side and the position of the other electrode may be mutually exchanged in the explanation described above.

[0006]

As described above, it is difficult to equalize current densities at positions in the organic layer in the plane, and therefore, for example, the following phenomenon may occur.

[0007]

· Occurrence of Luminance Unevenness

Since there are locations where a large amount of current passes and where only a small amount of current passes, luminance unevenness occurs throughout the element. The luminance of the organic electroluminescence element becomes high as the amount of passing current increases (see, for example, Non-Patent Document 1), and therefore if there are locations where a large amount of current passes and where a small amount of current passes, a difference in luminance occurs between the locations, resulting in luminance unevenness.

[0008]

Occurrence of Difference in Life in an Element

The life of the element changes in the location where a large amount of current passes and the location where only a small amount of current passes. Generally, the location where a large amount of current passes has shorter life duration. Therefore, compared to the element where a current passes equally, there is a location having shorter life duration. This shortens life of an organic electroluminescence element. If the element is used for a longer time, there arises a location that does not emit light or there arises a location having lower luminance compared to other locations.

[0009]

Problems such as Modifications

Since there are locations where a large amount of current passes and a portion where only a small amount of current passes, the element may be modified in different portions.

[0010]

Occurrence of Chromaticity Unevenness

Since there are locations where a large amount of current passes and where only a small amount of current passes, S-S annihilation phenomena may be occurred in an organic electroluminescence element using fluorescent

material, or T-T annihilation phenomena may be occurred in an organic electroluminescence using phosphorescent material. Therefore, in an electroluminescence element containing a plurality of light emitting materials in the light emitting layer such that each light emitting material emits light having a wavelength that is different from another light emitting material, luminance may be different in each layer in the locations where current easily passes and the locations where current is difficult to be passed. This may cause chromaticity unevenness.

[0011]

For solving this problem, various techniques have been proposed.

For example, there is a prior art in which unloading portions (the terminal portions described above) for application of voltages are provided at many locations (see, for example, Patent Document 1). However, the size of an apparatus such as a portable terminal in which the organic EL element is incorporated is limited, and therefore the size of the organic EL element is also limited. Thus, provision of a large number of unloading portions as in the prior art is effective for solving the problem described above, but is extremely difficult to employ from a practical viewpoint. In addition, provision of a plurality of terminal portions leads to a problem so that the proportion of the wirings for connecting the terminal portions to external drive circuit in the apparatus increases.

[0012]

A prior art in which an auxiliary electrode made of material having a lower volume resistivity is placed on an electrode made of material having a higher volume resistivity is known. For example, a technique in which the auxiliary electrode is placed in one edge at a position where front and back sides are opposite to each other between a light emitting layer (the organic layer described above) and a

transparent conductive film (the electrode described above) has been proposed (see, for example, Patent Document 2). This prior art is appropriately employed, but cannot completely solve the problem described above.

[0013]

A prior art in which in-plane thickness fluctuations of layers constituting the organic layer are set to a predetermined value (see, for example, Patent Document 3), and a prior art in which the thickness of a light emitting layer in the organic layer (organic light emitting region) is adjusted at each position in the light emitting layer so that the luminance is uniform in the plane (see, for example, Patent Document 4) have been proposed. These prior arts can be appropriately employed, but it is extremely difficult from a practical viewpoint to change the thickness of each layer on a position-by-position basis in production of the organic EL element. In addition, for realizing the techniques, a special manufacturing method should be employed, and a manufacturing apparatus for realizing the manufacturing method should be fabricated.

[0014]

A prior art relating to a line light source in which a light emitting region is segmented into a plurality of regions and the light emitting regions are connected in series has been proposed (see, for example, Patent Document 5). More specifically, it is a technique in which the values of currents passing through a plurality of thin film light emitting elements (light emitting regions) are connected in series to equalize the areas of each thin film light emitting element and equalize current densities in the light emitting elements, whereby the luminances of the thin film light emitting elements are equalized.

[Patent Document 1] Japanese Laid-Open Patent Publication No. 5-315073 (claim 1, paragraph [0002])

[Patent Document 2] Japanese Laid-Open Utility Model

Publication No. 5-20294 (claim 1)

[Patent Document 3] Japanese Laid-Open Patent Publication No. 11-339960 (claim 1)

[Patent Document 4] Japanese Laid-Open Patent Publication No. 11-40362 (claim 2, Fig. 1)

[Patent Document 5] Japanese Laid-Open Patent Publication No. 2000-173771 (paragraphs [0040]-[0046], paragraphs [0060]-[0065] Fig. 5, Fig. 7)

[Non-Patent Document 1] "Organic EL Elements and Front of Their Industrialization" supervised by Seizo Miyata, NTS CO., LTD., issued on 30 November, 1998, p. 46-47, Fig. 9

[DISCLOSURE OF THE INVENTION]

[PROBLEMS TO BE SOLVED]

[0015]

The present invention provides an organic electroluminescence element having a new configuration that substantially equalizes a value of current passing through a unit area in each position of an element.

[Means for Solving the Problems]

[0016]

To solve the above problems, a first aspect of the present invention provides an organic electroluminescence element having an organic layer that can emit light at least by application of an electric field to a pair of electrodes. In the element, an electrode made of material having a higher volume resistivity in the pair of electrodes is formed in a flat form. The organic layer has a plurality portions that do not emit light, and the portions are provided so that an area occupied by the portions per unit area is greater at a position physically closer to a position of a terminal portion of the electrode made of material having the higher volume resistivity that is connected to an external connection terminal.

[0017]

A second aspect of the present invention provides an

organic electroluminescence element having an organic layer that can emit light at least by application of an electric field to a pair of electrodes. In the element, an electrode made of material having a higher volume resistivity in the pair of electrodes is formed in a flat form. The organic layer has a portion that does not emit light, and the portion is provided so that an area occupied by the portion per unit area is greater at a position physically further to a position of a terminal portion of the electrode made of material having the higher volume resistivity that is connected to an external connection terminal.

[0018]

The first and second organic electroluminescence element is preferably formed such that an insulating layer is provided between at least one electrode of the pair of electrodes and the organic layer such that the portions that do not emit light do not emit light.

The element may have the organic layer provided only on the portions that emit light.

[0019]

In the organic electroluminescence, the portion that does not emit light in the organic layer is provided or the portion that emits light in the organic layer is provided so that the luminance is substantially uniform in the whole.

[Effects of the Invention]

[0020]

The present invention provides an organic electroluminescence element having a new configuration that substantially equalizes a value of current passing through a unit area in each position of an element.

[BEST MODE FOR CARRYING OUT THE INVENTION]

[0021]

An organic electroluminescence element according to one embodiment will be described below with reference to Figs. 1 to 4.

In Figs 1 to 4, same, equivalent or like members are given same numbers. In addition, Figs. 1 to 4 do not represent the actual organic EL element, but schematically show its configuration for explaining its configuration and the like, and the dimension of one or several parts is extremely exaggerated.

[0022]

Fig. 1 shows a schematic perspective view of a bottom emission type organic EL apparatus in which an organic EL element 1 according to the present invention is deposited on a transparent substrate 9, and light is extracted to outside from the side of the transparent substrate 9. The organic EL element shown in Fig. 1 has a transparent electrode 10, an organic layer 20 and a back electrode 30 formed in this order from the side of the transparent substrate 9. In Fig. 1, the back electrode 30 is drawn by a broken line for clarifying the configuration of the organic layer 20.

First, a light emitting portion 21 and non-light emitting portions 22 will be described.

[0023]

<Light emitting portion 21 and Non-light emitting portions 22>

The organic layer 20 is a layer which contains an organic light emitting material and emits light with a current passing when a voltage is applied between the transparent electrode 10 and the back electrode 30. More specifically, the organic layer 20 comprises a part 21 which actually emits light when a voltage is applied (referred to as a light emitting portion) and parts 22 which do not emit light (referred to as a non-light emitting portions).

[0024]

In this embodiment, the transparent electrode 10 is composed of a material having a volume resistivity higher than that of the back electrode 30, and a part denoted by reference numeral 11 in Fig. 1 is a terminal portion which is

connected to an external drive circuit. In addition, the volume resistivity of a material forming the back electrode 30 is negligible compared to the volume resistivity of a material forming the transparent electrode 10.

[0025]

In this configuration, in the organic layer 20, the area occupied by the non-light emitting portions 22 per unit area decreases as the distance from the terminal portion 11 becomes longer as shown in Fig. 2. In other words, the area occupied by the light emitting portion 21 per unit area increases as the distance from the terminal portion 11 becomes longer.

[0026]

By achieving the configuration described above, the amount of light emitted per unit area in the organic layer can be made substantially uniform irrespective of the distance from the terminal portion 11. This mechanism will be described below.

[0027]

As described previously, a current route extending from the terminal portion 11 of the transparent electrode 10 through the terminal portion 10 to the back electrode 30 by way of the organic layer 20 has a correlation with the length occupied by the transparent electrode 10 in this route. That is, a current route extending from the transparent electrode 10 to the back electrode 30 by way of the organic layer 20 at a position closer to the terminal portion 11 has a lower resistance value because the length occupied by the transparent electrode in this route is shorter. That is, a large amount of current passes through this route.

[0028]

The organic EL element 1 is designed so that the area occupied by the non-light emitting portions 22 per unit area is smaller at a position closer to the terminal portion 11. Namely, the area of the light emitting portion 21 per unit

area increases as going away from the terminal portion 11.

[0029]

Thus, in the organic layer 20, the current flowing amount increases but a current-passable area decreases as approaching the terminal portion 11. Conversely, the current flowing amount decreases but a current-passable area increases as going away from the terminal portion 11.

[0030]

Thus, by employing the configuration described above, the amount of current passing per unit area can be made substantially uniform irrespective of the distance from the terminal portion 11 in the organic layer 20. That is, this advantage can be obtained if the area occupied by the non-light emitting portions 22 per unit area is greater at a position closer to the terminal portion 11 composed of a material having a higher volume resistivity. In other words, the advantage can be obtained if the area occupied by the light emitting portion 21 per unit area is greater at a position more distant from the terminal portion 11.

[0031]

The optimum distribution of the non-light emitting portions 22 in the organic layer 20 varies depending on the performance of the organic element 1, namely the material and thickness of each layer constituting the organic EL element 1 and the manufacturing method, and therefore the organic EL element 1 may appropriately be designed in accordance with these conditions, but is preferably designed so that the luminance is substantially uniform in the whole. That is, the distribution of the non-light emitting portions 22 may be set so that the amount of light emitted by the organic layer per unit area is uniform when a general drive voltage (e.g. about 5 V) is applied between the transparent electrode 10 and the back electrode 30.

[0032]

In addition, the size of each non-light emitting

portion 22 in the plane direction of the organic layer 20 is preferably a level of size at which each non-light emitting portion 22 cannot be observed by the unaided eye when the organic EL element 1 is seen from outside, and generally, the distance between two most distant points within each non-light emitting portion 22 is about 300 μm or less. In addition, if a member having a diffusion capability such as, for example, a diffusion plate is provided on the light extraction side from the organic layer 20, the aforementioned distance is preferably about 500 μm or less.

A specific configuration of the non-light emitting portions 22 and a specific method for formation of the non-light emitting portions 22 will now be described.

[0033]

(Non-light emitting portions 22)

As described previously, each non-light emitting portion 22 is a part which does not emit light even if a voltage is applied between the transparent electrode 10 and the back electrode 30 in the organic EL element, and specifically, a region which does not emit light can be provided according to, for example, the configuration described below.

[0034]

(1) As shown in the cross-sectional view of Fig. 3, insulating portions 40 are provided on an area between the organic layer 20 and the transparent electrode 10 and/or an area between the organic layer 20 and the back electrode 30, which correspond to the non-light emitting portions 22.

That is, as shown in Fig. 3(a), the insulating portions 40 may be provided so as to contact a side of the organic layer 20 that corresponds to the back electrode 30 to form the non-light emitting portions 22, and as shown in (b), or the insulating portions 40 may be provided so as to contact a side of the organic layer 20 that corresponds to the transparent electrode 10 to form the non-light emitting

portions 22. Alternatively, as shown in (c), the insulating portions 40 may be provided on both sides of the organic layer 20.

Consequently, no electric charge (hole and/or electron) is injected into an area corresponding to each insulating portion 40 of the organic layer when a voltage is applied, and therefore no light is emitted from the organic layer 20 of the non-light emitting portions 22.

[0035]

For the insulating portions 40, an insulating material capable of being used in a publicly known organic EL element may be provided so as to contact the entire surface of the organic layer 20 in the non-light emitting portion using a publicly known thin film formation process such as a vapor deposition process or a CVD process.

[0036]

If the organic layer 20 employs a layered structure, the insulating portions 40 may be provided on at least one of layers constituting the organic layer 20.

[0037]

Materials for satisfying the above conditions may include, for example, transparent polymers, oxides and glass.

More specifically, preferred transparent polymers include polyimide, fluorinated polyimide, fluororesin, polyallylate, polyquinoline, polyoxadiazole, polyolefin having a cyclic structure, polyallylate, polycarbonate, polysulfone and ladder type polysiloxane.

[0038]

In addition, preferred oxides may include SiO_2, Al_2O_3, Ta_2O_3, Si_3N_4, fluorine-added SiO_2, MgO and YbO_3 as preferred examples of materials capable of being subjected to etching processing. Such materials are easily subjected to etching processing and therefore can form the insulating portions 40 into any (preferred) shape.

[0039]

Further, in addition to the aforementioned materials, a photosensitive photoresist and a cured product thereof may suitably be employed. This is because the insulating portions 40 can be processed into any shape as described above by a photoresist process.

[0040]

The organic layer 20 or the like is easily deteriorated by water, oxygen and the like, and therefore, a material having a water content of 0.1 wt% or less and a gas permeation coefficient (JISK 7126) of 1×10^{-13} cc·cm/(cm^2·s·cmHg) or less is preferably employed. Such materials include, for example, inorganic oxides, inorganic nitrides and compositions of the oxides and nitrides.

[0041]

The insulating portions 40 may have a function of transmitting light of a wavelength emitted from the organic layer 20 (transmission function), a function of scattering the light (scattering function), a function of reflecting the light (reflection function) and the like.

[0042]

The insulating portions 40 preferably have a function of reflecting light of a wavelength emitted from the organic layer 20 (reflection function) if the insulating layer 40 is provided on a side opposite to the light extraction side of the organic layer 20 and particularly, the back electrode 30 has a reflection function. Consequently, the traveling direction of light emitted from the organic layer 20 and emitted to a side opposite to the light extraction side can be diverted to the light extraction side. In addition, the non-light emitting portions 21 do not emit light, but light exits therefrom to some degree, and therefore the possibility of being determined as a "dark spot" (observed by the naked eye) can extremely be reduced.

[0043]

If the back electrode 30 has a function of absorbing

light emitted from the organic layer 20 (absorption function) for the purpose of improving the contrast and the like, the insulating layer 40 is preferably made to have an absorption function. For making the insulating portions 40 have an absorption function, a material absorbing the light may be selected from the materials described above to form the insulating portions 40 when the insulating portions 40 are formed. Alternatively, only the periphery of each insulating portion 40 may be made of such material.

[0044]

In addition, the insulating portions 40 may have a transmission function. Consequently, light emitted from the organic layer 20 to a side opposite to the light extraction side can be allowed to arrive at the back electrode 30. That is, if having a function such as, for example, a reflection function, the back electrode 30 can exhibit the function even in the non-light emitting portions 22 as in the light-emitting portion 21.

Of course, the insulating layer 40 can be made to have any other known function other than the aforementioned capabilities.

[0045]

For making the non-light emitting portions 22 have a transmission function, the insulating portions 40 may be fabricated using a material which is transparent to the light when formed into the insulating portions 40 among the materials described above. In addition, the scattering function can be achieved by a known method such as a method in which beads or the like made of material having a different refractive index are dispersed in each insulating portion 40. The reflection function can be achieved by selecting a material having a reflection function from the materials described above to form the insulating portions 40. Alternatively, reflection members may be provided to adjoin each insulating portion 40 separately from the insulating

portion 40.

The scattering function and the reflection function may be provided only in a part of each insulating portion 40, such as only the surface of the insulating portion 40.

[0046]

(2) In the non-light emitting portions 22, at least one of the transparent electrode 10, the organic layer 20 and the back electrode 30 is not provided.

The non-light emitting portions 22 can be formed even if, for example, the organic layer 20 in the non-light emitting portions 22 is not provided as shown in Fig. 4(a), the back electrode 30 in the non-light emitting portions 22 is not provided as shown in (b), or the transparent electrode 10 in the non-light emitting portions 22 is not provided as shown in (c). Of course, the non-light emitting portions 22 can be constructed even if none of these layers or even no layer is provided.

[0047]

If the configuration described above is employed, no current passes through the organic layer 20 or no organic layer 20 is provided, and therefore light is not emitted from the non-light emitting portions 22. In other words, the organic layer 22 or the like is provided in only the light emitting portion 21.

In addition, if this configuration is employed, the amount of material required for forming the organic EL element 1 can be reduced as a result of not providing some layer in the non-light emitting portions 22.

[0048]

For creating such a configuration, for example, the following manufacturing method may be employed.

· The transparent electrode 10 and the like are provided on only the light emitting portion 21 using a method for forming a thin film on a fine region using a mask or the like.

· The transparent electrode 10 and the like are provided

using a method allowing a thin film to be formed on a fine region, such as a printing method.

· The transparent electrode 10 and the like are provided, and the transparent electrode 10 and the like on an area corresponding to the non-light emitting portions 22 are then removed using a known fine processing method (removal method) such as mechanical removal, dry etching or wet etching.

[0049]

In addition, a protective member for protecting the organic EL element 1 may be placed at a location in the non-light emitting portions 22 where the transparent electrode 10 and the like are not provided. This is intended for preventing existence of a material, such as air, deteriorating the organic EL element 1 in the region or maintaining the flatness of each layer constituting the organic EL layer 1. For example, if the organic layer 20 and the back electrode 30 are provided on a region where no transparent electrode 10 is provided, steps may arise in the organic layer 20 and the back electrode 30.

[0050]

(3) At least one of the transparent electrode 10 and the organic layer 20 in the non-light emitting portions 22 is made to have a thickness greater than that in the light-emitting portion 21.

The organic layer 20 has a higher volume resistivity, and therefore if the aforementioned configuration is employed, the specific resistance of a current route extending through the non-light emitting portions 22 increases, a current becomes hard to pass compared to the light emitting portion 21, and substantially, light is no longer emitted.

[0051]

(4) The organic layer 20 is modified so that light is not emitted even when a voltage is applied.

The organic layer 20 is substantially uniformly formed on the transparent electrode 10, and the organic layer 20 is

then modified by applying an ultraviolet ray or a laser to the organic layer 20 situated on the non-light emitting portions 22, so that light is not emitted even when a voltage is applied. The region thus processed may be determined to be the non-light emitting portions 22.

A general configuration of the organic layer 20, a method for manufacturing the same, and so on will now be described.

[0052]

<Organic Layer 20>

The organic layer 20 is a layer provided between the transparent electrode 10 and the back electrode 30 and containing an organic light emitting material that emits light when a voltage is applied to the electrodes, a known layer structure in a known organic EL element and a known material may be used for the organic layer 20, and the organic layer 20 may be manufactured by a known manufacturing method.

[0053]

The organic layer 20 may have any structure as long as the organic layer achieves at least the following functions, and for example, the organic layer may have a layered structure, in which each layer performs one of the following functions, or a single layer structure, by which the following functions are achieved.

· Electron Injection Function

A function to inject electrons from the electrode (cathode). Electron injection property.

· Hole Injection Function

Holes (holes) are injected from the electrode (anode). Hole injection

· Carrier Transport Function

A function to transport at least either electrons and holes. Carrier transport property.

A function for transporting electrons is referred to as

an electron transport function (electron transport property) and a function for transporting holes is referred to as a hole transport function (hole transport property).

· Light Emitting Function

A function to generate excitons (create an excitation state) by recombining injected and transported electrons and holes and to emit light when returning to a base state.

[0054]

When the transparent electrode 10 is an anode, the organic layer 20 may be constructed by, for example, providing a hole injection transport layer, a light emitting layer and an electron injection transport layer in this order from the side corresponding to the transparent electrode 10.

[0055]

The hole injection transport layer is a layer for transporting holes from the anode to the light emitting layer. A material for forming the hole transport layer may be selected from, for example, low molecular materials such as metal phthalocyanines such as copper phthalocyanine and tetra(t-butyl)copper phthalocyanine, nonmetal phthalocyanines, quinacridone compounds, and aromatic amines such as 1,1-bis(4-di-p-tolylaminophenyl)cyclohexane, N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine, and N,N'-di(1-naphthyl)-N,N'-diphenyl-1,1'-biphenyl-4,4'-diamine, polymeric materials such as polythiophene and polyaniline, polythiophene oligomer materials, and other existing hole transport materials.

[0056]

The light emitting layer is a layer that is excited by recombining holes transported from the anode with electrons transported from cathode, and emits light when returning to base state from excited state. As material for the light emitting layer, fluorescent material or phosphorescent material may be employed. A dopant (fluorescent material or phosphorescent material) may be included in the host material.

[0057]

As materials for forming the light emitting layer, for example, low molecular materials such as 9,10-diallylanthracene derivative, pyrene derivatives, coronene derivatives, perylene derivatives, rubrene derivatives, 1,1,4,4-tetraphenylbutadiene, tris(8-quinolinolate)aluminum complexes, tris(4-methyl-8-quinolinolate)aluminum complexes, bis(8-quinolinolate)zinc complexes, tris(4-methyl-5-trifluoromethyl-8-quinolinolate)aluminum complexes, tris(4-methyl-5-cyano-8-quinolinolate)aluminum complexes, bis(2-methyl-5-trifluoromethyl-8-quinolinolate)[4-(4-cyanophenyl)phenolate]aluminum complexes, bis(2-methyl-5-cyano-8-quinolinolate)[4-(4-cyanophenyl)phenolate]aluminum complexes, tris(8-quinolinolate)scandium complexes, bis[8-(para-tosyl)aminoquinoline]zinc complexes, cadmium complexes, 1,2,3,4-tetraphenylcyclopentadiene, pentaphenylcyclopentadiene, poly-2,5-diheptyloxy-para-phenylenevinylene, coumarin phosphors, perylene phosphors, pyran phosphors, anthrone phosphors, porphyrin phosphors, quinacridone phosphors, N,N'-dialkyl substituted quinacridone phosphors, naphthalimide phosphors, N,N'-dialyl substituted pyrrolopyrrole phosphors, polymeric materials such as polyfluorene, polyparaphenylenevinylene, and polythiophene, and other existing luminescent materials may be used. When employing a host-guest structure, the host and the guest (dopant) may be selected from the above material.

[0058]

The electron injection transport layer is a layer that transports electrons from the cathode (in this example, a back electrode 30) to the light emitting layer. Materials for forming the electron transport layer include, for example, 2-(4-biphenylyl)5-(4-t-butylphenyl)-1,3,4-oxadiazole, 2,5-bis(1-naphthyl)-1,3,4-oxadiazole, oxadiazole derivatives, bis(10-hydroxybenzo[h]quinolinolate) beryllium complexes, and triazole compounds.

[0059]

The organic layer 20 may be provided with layers that can be employed in a known organic electroluminescence layer such as a buffer layer, a hole block layer, an electron injection layer, and a hole injection layer as a matter of course. The layers can be provided using a known material and a known manufacturing method. For example, the electron injection transport layer may be separated into an electron injection layer that is in charge of electron injection function and an electron transport layer that is in charge of electron transport function, which are then laminated to each other. Material for forming each layer may be selected as required from known material in accordance with the function of the layer. That is, material for forming each layer may be selected from the above listed materials for forming the electron injection transport layer.

The transparent electrode 10 and the back electrode 30 will now be described at the same time.

[0060]

<Electrodes>

One of the transparent electrode 10 and the back electrode 30 functions as an anode, and the other functions as a cathode. In this embodiment, any one of the electrodes may be an anode (or cathode). First, the anode will be described.

[0061]

(Anode)

The anode is an electrode for injecting holes into the organic layer 20.

The material for forming the anode may be any material as long as the material imparts the aforementioned properties to the electrode, and in general, a known material such as a metal, an alloy, an electrically conductive compound or a mixture thereof is selected. The anode is manufactured such that a work function of a surface contacting the anode is 4

eV or more.

[0062]

Examples of material used for forming the anode are listed below:

metal oxides and metal nitrides such as ITO (indium-tin-oxide), IZO (indium-zinc-oxide), tin oxide, zinc oxide, zinc aluminum oxide and titanium nitride;

metals such as gold, platinum, silver, copper, aluminum, nickel, cobalt, lead, chromium, molybdenum, tungsten, tantalum and niobium;

alloys of above listed metals, alloys of copper iodide, and the like; and

conductive polymers such as polyaniline, polythiophene, polypyrrole, polyphenylenevinylene, poly(3-methylthiophene) and polyphenylene sulfide.

[0063]

When the transparent electrode 10 is an anode, a setting is generally made so that the transmittance for light to be extracted becomes greater than 10%. When extracting light in a visible region, ITO having a high transmittance in a visible region is suitably used.

[0064]

When the back electrode 30 is an anode, the electrode is preferably constructed as a reflecting electrode. In this case, a material having a function of reflecting light to be extracted to outside is selected as required among the aforementioned materials, and in general, a metal, an alloy or a metallic compound is selected.

For preventing a contrast or the like, and reflection of external light, the back electrode 30 may be made to have an absorption function. For making the back electrode 30 having the absorption function, a material exhibiting the absorption function when forming the electrode may appropriately be selected from the materials listed above.

[0065]

The anode may be made of one kind of the above mentioned material or a mixture of materials. The anode may have a multilayered structure comprising multiple layers of the same composition or different compositions.

[0066]

The thickness of the anode depends on the material used but is generally selected within the range of about 5 nm to 1 μm, more preferably about 10 nm to 1 μm, further preferably about 10 nm to 500 nm, particularly preferably about 10 nm to 300 nm, and desirably about 10 nm to 200 nm.

[0067]

The anode is formed using the above mentioned materials by a known film formation process such as a sputtering process, an ion plating process, a vacuum deposition process, a spin coating process and an electron beam evaporation process.

The sheet electric resistance of the anode is preferably equal to or less than several hundreds Ω/□ (ohm per square), more preferably about 5 to 50 Ω/□ (ohm per square).

[0068]

The surface of the anode may be subjected to UV/ozone cleaning or plasma cleaning.

For inhibiting short circuits of the organic EL element and occurrence of defects, the surface roughness may be controlled to be equal to or less than 20 nm as a root mean square value by a method of reducing the particle diameter or a method of polishing after forming a film.

[0069]

(Cathode)

The cathode is an electrode for injecting electrons into the organic layer 20 (electron injection transport layer in the layer structure described above).

To increase the efficiency of the electron injection, a metal, an alloy, an electrically conductive compound, or a

mixture thereof having a work function that is, for example, less than 4.5 eV, generally equal to or less than 4.0 eV, typically equal to or less than 3.7 eV, is used as a material for forming the cathode.

[0070]

Electrode materials for forming the cathode include, for example, lithium, sodium, magnesium, gold, silver, copper, aluminum, indium, calcium, tin, ruthenium, titanium, manganese, chrome, yttrium, aluminum-calcium alloys, aluminum-lithium alloys, aluminum-magnesium alloys, magnesium-silver alloys, magnesium-indium alloys, lithium-indium alloys, sodium-potassium alloys, magnesium/copper mixtures and aluminum/aluminum oxide mixtures. A material that can be employed as a material for forming the anode may also be used for the cathode.

[0071]

When the back electrode 30 is a cathode, a material having a function of reflecting light to be extracted to outside is preferably selected among the materials described above, and in general, a metal, an alloy or a metallic compound is selected.

[0072]

When the transparent electrode 10 is a cathode, a setting is generally made so that the transmittance for light to be extracted becomes greater than 10%, and for example, an electrode formed by laminating a transparent conductive oxide to a very thin magnesium-silver alloy, or the like, is employed. In the cathode, a buffer layer containing copper phthalocyanine or the like is preferably provided between the cathode and the organic light-emitting layer 20 to prevent the light-emitting layer and other components from being damaged by plasma when sputtering the conductive oxide.

[0073]

The cathode may be made of single material or several materials. For example, if 5% to 10% of silver or copper is

added to magnesium, the cathode is prevented from being oxidized and the adhesiveness between the cathode and the organic layer 20 is improved.

[0074]

The cathode may have a multi-layered structure comprising multiple layers of the same composition or different compositions. For example, the cathode may have the following structure.

· To prevent oxidation of the cathode, a protective layer made of corrosion-resistant metal is provided at part of the cathode that does not contact the organic layer 20.

As material for forming the protective layer, for example, silver or aluminum is preferably used.

[0075]

· An oxide, a fluoride, or a metallic compound having a small work function is inserted in the boundary portion between the cathode and the organic layer 20 to reduce the work function of the cathode.

For example, the material of the cathode is aluminum, and lithium fluoride or lithium oxide is inserted in the boundary portion.

[0076]

The cathode is formed by a known film formation process such as a vacuum deposition process, a sputtering process, an ionization deposition process, an ion plating process, and an electron beam evaporation process.

The sheet electric resistance of the cathode is preferably set to several hundreds Ω/□ or less.

Next, layers and members that are preferably employed in the organic EL element 1 will be described.

[0077]

(Insulating Layer)

An insulating layer is preferably provided on the outer periphery of the organic layer 20 to prevent the transparent electrode 10 and the back electrode 30 from being short-

circuited. By providing the insulating layer, the transparent electrode 10 and the back electrode 30 in electrically adjacent light emitting regions T can also be prevented from contacting the organic layer 20.

As material for forming the insulating layer, a material for forming the insulating layer, which is employed in a known organic EL element, may appropriately be employed, and for example, the above described materials for forming the insulating portions 40 may be employed. As a method for forming the insulating layer, a known formation method may be employed, and for example, a sputtering process, an electron beam deposition process, a CVD process or the like may be employed.

[0078]

(Auxiliary Electrode)

An auxiliary electrode can be provided as a matter of course. The auxiliary electrode is electrically connected to the anode and/or cathode. The auxiliary electrode is made of material having the volume resistivity that is lower than that of the electrode to which the auxiliary electrode is connected. If the auxiliary electrode is made of such material, the volume resistivity of the entire electrode provided with the auxiliary electrode can be decreased, thus making it possible to reduce the maximum difference of the level of current that flows through each point forming the organic layer 20 as compared to a case where the auxiliary electrode is not provided.

[0079]

Materials for forming the auxiliary electrode may include, for example, tungsten (W), aluminum (Al), copper (Cu), silver (Ag), molybdenum (Mo), tantalum (Ta), gold (Au), chrome (Cr), titanium (Ti), neodymium (Nd), and alloys thereof.

Specific examples of the alloys may include Mo-W, Ta-W, Ta-Mo, Al-Ta, Al-Ti, Al-Nd, and Al-Zr alloys. Further, as

material for forming an auxiliary wiring layer, compounds of metal and silicon, which are $TiSi_2$, $ZrSi_2$, $HfSi_2$, VSi_2, $NbSi_2$, $TaSi_2$, $CrSi_2$, WSi_2, $CoSi_2$, $NiSi_2$, PtSi, Pd_2Si and the like are preferable. The auxiliary wiring layer may be formed by laminating the metal and silicon compounds.

[0080]

The auxiliary electrode may be a single layer film made of the above described material, but is also preferably a multilayered film including two or more layers for improving the stability of the film. Such a multilayered film may be formed using the above described metals and alloys thereof. For example, combinations of a Ta layer, a Cu layer and a Ta layer, and a Ta layer, an Al layer and a Ta layer may be used for the three-layer film, and combinations of an Al layer and a Ta layer, a Cr layer and an Au layer, a Cr layer and an Al layer, and an Al layer and a Mo layer may be used for the two-layer film.

The stability of a film means a property that allows a low volume resistivity to be maintained and makes the film resistant to corrosion by a liquid or the like that is used in processing such as etching. For example, if the auxiliary electrode is made of Cu or Ag, the auxiliary electrode may be prone to corrosion although its volume resistivity is low. By laminating a film made of metal excellent in corrosion resistance, for example Ta, Cr or Mo, to the topside and the underside, or one of the sides, of the metallic film made of Cu or Ag as a counter measure, the stability of the auxiliary electrode can be improved.

[0081]

In general, the thickness of the auxiliary electrode is preferably in a range of 100 nm to several tens of μm, and particularly preferably within the range of 200 nm to 5 μm.

The reason for this is that if the thickness is less than 100 nm, the resistance value is increased, which is not preferable for the auxiliary electrode, and on the other hand,

if the thickness exceeds several tens of μm, planarization of the auxiliary electrode becomes difficult, thus raising the possibility of occurrence of defects in the organic EL elements 1.

[0082]

The width of the auxiliary electrode is preferably within the range of 2 μm to 1,000 μm, and more preferably within the range of 5 μm to 300 μm.

The reason for this is that if the width is less than 2 μm, the resistance of the auxiliary electrode might be increased, and on the other hand, if the width exceeds 100 μm, the auxiliary electrode might hinder light from being extracted to outside.

[0083]

(Protective Layer: Passivation Film and Sealing Can)

For protecting the organic layer 20 and the like from outside air, the organic EL element 1 may be protected with a passivation film or a sealing can.

[0084]

The passivation film is a protective layer (sealing layer) that is provided on a side opposite to the substrate 9 for preventing the organic EL element 1 from contacting oxygen and water. Materials that are used for the passivation film may include, for example, organic polymeric materials, inorganic materials and further, photocurable resins. The material that is used for the protective layer may be a single material or a combination of two or more materials. The passivation film may have any thickness as long as water or gas from outside can be blocked.

[0085]

Examples of the organic polymer material may include fluorocarbon resins such as chlorotrifluoroethylene polymers, dichlorodifluoroethylene polymers, and copolymers of chlorotrifluoroethylene polymer and dichlorodifluoroethylene polymer, acrylic resins such as polymethyl methacrylate and

polyacrylate, epoxy resins, silicon resins, epoxy silicone resins, polystyrene resins, polyester resins, polycarbonate resins, polyamide resins, polyimide resins, polyamide-imide resins, polyparaxylene resins, polyethylene resins, and polyphenylene oxide resins.

[0086]

Examples of the inorganic material may include polysilazane, diamond films, amorphous silica, electrical insulation glass, metal oxides, metal nitrides, metal carbides and metal sulfides.

[0087]

The sealing can is a member constituted by a sealing member such as a sealing plate and a sealing container for blocking water and oxygen from outside. The sealing can may be provided only on the electron side on the back side (side opposite to the substrate 9), and the entire organic EL element 1 may be covered with the sealing can. The shape, the size, the thickness and the like of the sealing member are not specifically limited as long as the sealing member can seal the organic EL element 1 and block outside air. Materials that are used as the sealing member may include glass, stainless steels, metals (aluminum and the like), plastics (polychlorotrifluoroethylene, polyester, polycarbonate and the like) and ceramics.

[0088]

A sealant (adhesive) may appropriately be used when the sealing member is placed on the organic EL element 1. When the entire organic EL element 1 is covered with the sealing member, the sealing member is heat-sealed without using a sealant. As the sealant, an ultraviolet cured resin, a thermosetting resin, a two liquid cured thermosetting resin or the like may be used.

[0089]

A moisture absorbent may be inserted in a space between the passivation film or sealing can and the organic EL

element 1. The moisture absorbent is not specifically limited, and specific examples of the moisture absorbent include barium oxide, sodium oxide, potassium oxide, calcium oxide, sodium sulfate, calcium sulfate, magnesium sulfate, phosphorus pentoxide, calcium chloride, magnesium chloride, copper chloride, cesium fluoride, niobium fluoride, calcium bromide, vanadium bromide, molecular sieve, zeolite and magnesium.

[0090]

An inactive gas may be included in the passivation film or the sealing can. The inactive gas refers to a gas that does not react with the organic EL element 1, and for example, noble gases such as helium and argon, and nitrogen gas may be employed.

The substrate 9 will now be described.

[0091]

<Substrate 9>

The substrate 9 is principally a flat member that supports the organic EL element 1. The organic EL element 1 is constituted by very thin layers, and is therefore fabricated as an organic EL apparatus supported on the substrate 9 in general.

[0092]

The substrate 9 is a member to which the organic EL element 1 is laminated, and therefore the substrate preferably has plane smoothness.

The substrate 9 is transparent to light to be extracted when the substrate 9 is situated on the light extraction side from the organic layer 20. Since the organic EL element 1 is a bottom emission type element, the substrate 9 is transparent, and a flat surface 90 of the transparent substrate 9 opposite to a flat surface contacting the organic EL element 1 is a light extraction surface.

[0093]

For the substrate 9, known members may be used as long

as the members have the aforementioned function. In general, a ceramics substrate, such as a glass substrate, a silicon substrate, and a quartz substrate, or a plastic substrate is selected. A metal substrate or a substrate made by forming a metal foil on a support is used. Further, a substrate formed of a compound sheet, in which the same type or different types of substrates are combined, may be used.

[0094]

In the above example, the bottom emission type organic EL apparatus having the transparent electrode 10, the organic layer 20 and the back electrode 30 formed in order on the substrate 9 is shown, but of course, the organic EL element may be constructed as the organic EL element 1 having no transparent substrate 9 rather than constructing the organic EL element as the organic EL apparatus. In this case, the organic EL element 1 may be manufactured without using the substrate 9 from the initial stage, or the organic EL element 1 may be manufactured by removing the substrate 9 by a known substrate removal technique such as etching after fabricating the organic EL apparatus.

The organic EL element may be constructed as a top emission type apparatus or an apparatus in which light is extracted from both sides as described previously.

[0095]

That is, for manufacturing the bottom emission type organic EL element 1, the transparent electrode 10, the organic layer 20 and the back electrode 30 may be formed on the substrate 9 using the aforementioned film formation process. For manufacturing the top emission type organic EL element, the back electrode 30, the organic layer 20 and the transparent electrode 10 may be formed in order on the substrate 9.

The operation and the advantages of the organic EL element 1 will now be described.

[0096]

<Operation and Advantages>

The transparent electrode 10 and the back electrode 30 in the organic EL element 1 are connected to an external drive circuit at their terminals 11 and 31. When a voltage is applied to the organic EL element by the external drive circuit, a voltage is applied to the organic layer. At this time, the light emitting zone 21 emits light, and the non-light emitting zones 22 do not emit light.

[0097]

As described previously, the non-light emitting zones occupy larger area per unit area at a position closer to the terminal portion 11 of an electrode having a higher volume resistivity (in this example, transparent electrode 10). The current size passing through the organic layer 20 is higher at a position closer to the terminal portion 11. Thus, in unit area of the organic layer 20, the amount of current passing through the organic layer 20 can be almost equalized according to the distance from the terminal portion 11.

The operations and advantages described in the explanations described previously can be obtained as a matter of course.

[0098]

In the embodiments described above, the organic EL element is an element suitable for an illuminator, a backlight or the like, which emits light from the whole surface, but the above described element can be applied for pixels or sub-pixels in an organic EL display employing an active matrix system or a passive matrix system as a matter of course.

The above described organic EL apparatus is of bottom emission type, but the organic EL element may be constructed as a top emission type, or constructed so that light can be extracted from opposite sides as a matter of course.

[0099]

In the explanations described above, the transparent

electrode is an electrode made of material having a volume resistivity higher than that of the back electrode, but of course, the present invention may be applied to an organic EL element in which the back electrode is made of material having a volume resistivity higher than that of the transparent electrode. In this case, the positions of the non-light emitting portion and the light emitting portion may be specified in reference to the back electrode and the terminal portion in the explanations described above.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0100]

[Fig. 1] A perspective view for explaining a configuration of an organic EL element according to the present embodiment. In this drawing, a back electrode 30 is shown by a dotted line for facilitating the explanation of a light emitting portion 21 and a non-light emitting portion 22.

[Fig. 2] A front view for explaining an organic layer 20 according to the present embodiment. In this drawing, a terminal portion 11 of a transparent electrode is shown other than the organic layer 20 for the explanation.

[Fig. 3] A drawing schematically showing a cross-sectional configuration of the organic EL element for explaining a first example of the configuration of the light emitting portion 21 and the non-light emitting portion 22 according to the present embodiment

[Fig. 4] A drawing schematically showing a cross-sectional configuration of the organic EL element for explaining a second example of the configuration of the light emitting portion 21 and the non-light emitting portion 22 according to the present embodiment

[DESCRIPTION OF THE REFERENCE NUMERALS]

[0101]

1: organic EL element, 9: substrate (transparent substrate), 10: transparent electrode, 11: terminal portion of the transparent electrode, 20: organic layer, 21: light

emitting portion, 22: non-light emitting portion, 30: back electrode, 31: terminal portion of the back electrode, 40: insulating portion

[Title of the Document] ABSTRACT

[Abstract]

[Problem to be solved]

To provide an organic electroluminescence element provided with a new configuration that makes the level of current passing per unit area to be substantially uniform at each position on the element.

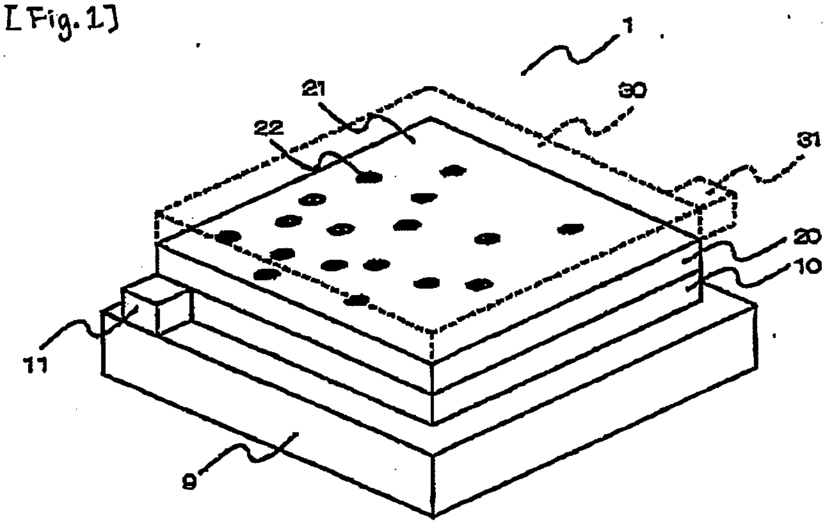
[Solution]

An element has at least an organic layer 20 held between a pair of electrodes 10, 30. At least an electrode 10 made of material having a higher volume resistivity, of the pair of electrodes, is formed in a flat shape. The organic layer 20 is provided with a plurality of portions that does not emit light (non-light emitting portions) 22. The non-light emitting portions 22 are provided so that a larger number of non-light emitting portions exist per unit area at a position physically closer to the position of a terminal portion 11 at which the electrode 10 made of material having the higher volume resistivity is connected to an external connection terminal.

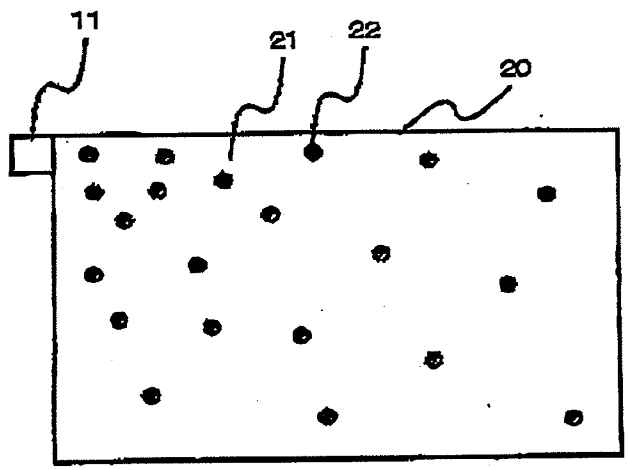
[Selected Drawing] Fig. 1

[Title of Document] Drawings

[Fig. 1]

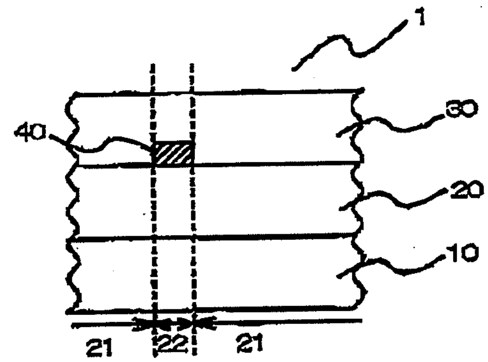


[Fig. 2]



[Fig.3]

(a)



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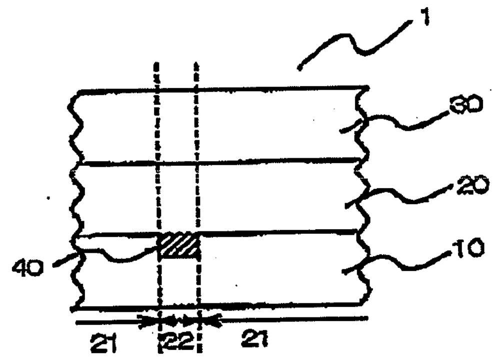

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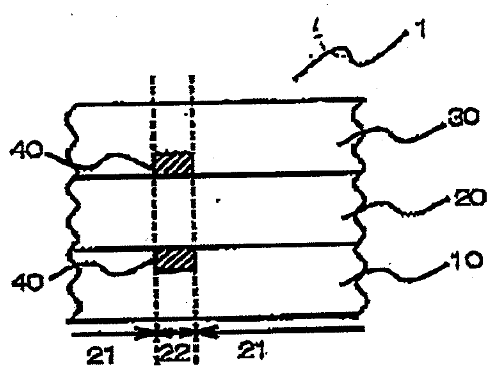
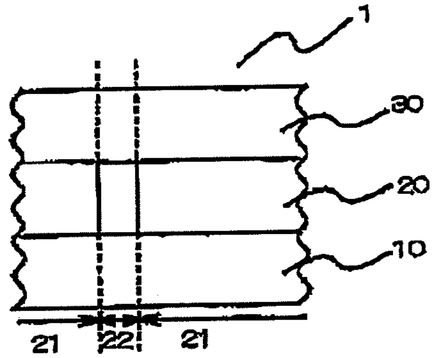


[Fig.4]

(a)



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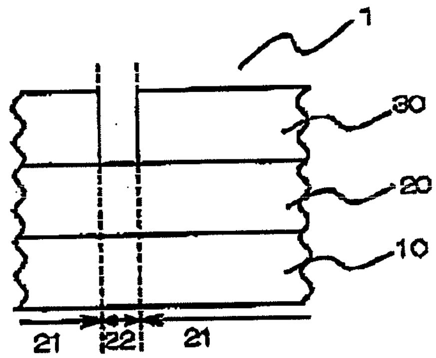

(c)